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ANALYSIS OF CARDIAC RHYTHM DURING ATHEROSCLEROSIS AND HYPERTONIA IN SURGICAL PATIENTS USING A SPECIALIZED COMPUTER

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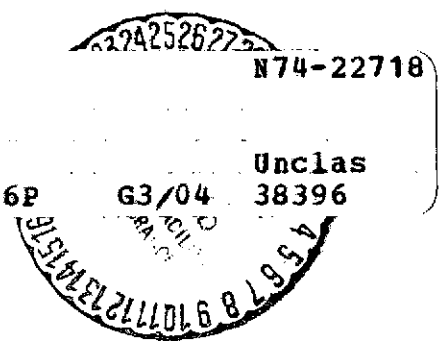

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16. Abstract

The authors measured 400 intervals on the ECG with an accuracy to 1 msec in 64 patients and 30 healthy individuals. The authors analyzed interval histograms and cardiointervalograms presented in figures and graphic form, ECG, polycardiograms, respiration curves. The cardiac rhythm was more stable in patients than in healthy individuals, especially in cases of marked changes in the contractile capacity of the myocardium. In the group of patients with a more variable rhythm, there were observed changes in the conducting system of the heart. Dynamic observations in the course of the preoperative preparation showed that variability criteria can be used for the control of the conducted therapy.

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ANALYSIS OF CARDIAC RHYTHM DURING ATHEROSCLEROSIS AND HYPERTONIA IN SURGICAL PATIENTS USING A SPECIALIZED COMPUTER

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At the present time, thanks to the improvement of operating /19* technique and narcosis, the number of operations performed upon middle-aged patients with associated hypertonic illnesses and atherosclerosis has increased. Therefore, there is an increased requirement for evaluating the functional condition of the cardiovascular system prior to the operation to determine the amount of risk of surgical intervention, the correct choice of pre-operation preparation and anesthesia.

Cardiologists have become interested in methods for mathematical analysis of cardiac rhythm with longer observation of heart activity (registration of 100-400 R-R intervals), than during the normal ECG interpretation (4-5 intervals).

An experiment for prolonged, continuous registration of cardiac intervals and their statistical evaluation was described in 1932 by Fleisch and Beckmann. The authors showed that, apart from the average rhythm rate, it is diagnostically important to have its variability, which is especially expressed in young healthy people. The rhythm becomes stable with the increase and development of pathological changes in the heart. They isolated the periodic fluctuations of respiratory and non-respiratory origin, the so-called respiratory and slow waves (RW and SW). The SW /20 of the first order, according to the Fleisch and Beckmann classification, has a period T = 10 sec, the second order -- from 15 to 25 sec and the third order -- approximately 1 min. By using

*Numbers in the margin indicate pagination in the foreign text.

improved techniques and computers for analysis, these results were confirmed and new information was obtained on the variability and wave structure of cardiac rhythm (R.M. Bayevskiy et al.; D. Zhemaytite; A.D. Voskresenskiy).

Special investigation into the rhythm of patients with ischemic disease was conducted by D. Zhemaytite during 1965-1972. The author showed that with the development of pathological changes, the variability of rhythm decreased, the RW and SW amplitude was sharply reduced, as was that of cardiac reaction to functional tests.

When researching into surgical patients, we confirmed the diagnostic importance of the described methods and obtained new information, and this led us to study the results more carefully. Ninety-four individuals were studied, of them 64 were patients and 30 were healthy individuals.

The patients with various manifestations of ischemic disease of the heart, aged between 40 and 78, were in the Faculty Surgical Clinic im. N.N. Burdenko, because of atherosclerosis of the lower extremities (18), cholelithiasis (4), various oncologic (25) and other surgical diseases (17). There were 13 people between 40 and 50 years of age, 14 from 50 to 60, 28 from 60 to 70 and nine from 70 to 80 years of age. We did not include a larger number of surgical patients in the analyzed group.

Two subgroups (first and second) were formed from patients with general atherosclerosis and various manifestations of ischemic disease of the heart. Among patients of the first subgroup without hypertonia (41), cicatricial changes of the myocardium in different locations were detected in 16, various forms of extrasystole in 11 and changes in the contractile capacity of the myocardium and hypodynamia syndrome, according to phase-shift analysis, in 14.

Among patients of the second subgroup (23), 18 had stage IIB-III hypertonia and five patients, stage IIA. Ten patients had various forms of extrasystole and 12 patients with stage IIB-III hypertonia had a hypodynamia syndrome, and one patient suffered microinfarction a year before the research.

The control group consisted of 30 healthy individuals aged between 20 and 56.

Cardiointervalograms (CIG) and histograms for determining the R-R intervals (IG) by using a "Mediak" MS-401 computer, produced by the "SAN-EY" firm (Japan) were used for recording and studying the structure of cardiac rhythm.

The machine automatically measures the R-R interval with an accuracy of up to 1 msec. When registering with the CIG, the values obtained were set out along the Y-axis, the serial number of the interval along the axis of X.

After accumulating 400 intervals on the computer screen, one can see the envelope of interval length (CIG). IG for 400 R-R intervals was also done automatically. The discharge value chosen was 5 msec, based on statistical criteria.

Statistical indices were calculated according to the IG obtained in digital form: the average value of the R-R interval (M) for each examinee, the average quadratic deviation (σ), asymmetry and excess indices (A, E).

They also determined the average interval value R-R and the average quadratic deviation for each group ($\overline{M}$ and $\overline{\sigma}$)[1]. Apart

[1]Confidence intervals for M and σ on the groups were determined by the generally accepted method by using the Student and Fisher criteria with a probability P = 95%.

from this, curves of the CIG were evaluated visually, wave periods and their amplitude were determined manually with allowance for scale marks.

ECG and polycardiograms were recorded simultaneously in 12 contact points. Cardiac contraction phases were evaluated according to the Blumberg method, modified by V.P. Karpman.

Healthy group. The RW with a period T = 3.5 sec and SW with /21 a period of T = 7-20 and 40-120 sec which were arbitrarily designated SW-1 and SW-2, were well expressed on the CIG of healthy individuals. RW were shown best in young, physically fit individuals (between 20 and 23 years of age). Precise, regular SW-2 were noted in individuals with a labile rhythm, and were often accompanied by a marked respiratory activity. During a repeat investigation, 4-6 months later, these waves did not disappear, maintaining the same period. Apart from this, we observed episodes of momentary slowing down or increase of the cardiac rhythm -- "aperiodic fluctuations," which often appeared during deep breathing or breath holding and apparently were of a reflex nature. The period of these fluctuations was 10-18 sec.

In Fig. 1 are shown histograms of the distribution of M for healthy individuals. Values for M are found in the limits 0.655-1.116 sec. The m e a n value of M for group $\overline{M} = 0.91 \pm 0.04$ sec.

On a histogram for the distribution of σ (Fig. 2) it can be seen that values of σ are in the limits of 0.029-0.11 sec. The m e a n value of σ for the group is $0.077 > \sigma > 0.045$. Values of $\sigma < 0.05$ were observed in older people of the group and in young people who were upset before the research (the first peak of the histogram). The majority of young, physically fit individuals showed a greater value of σ (second peak). When the rhythm was

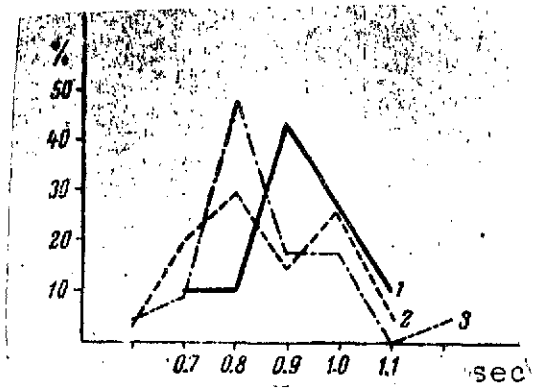

Fig. 1. Distribution of M. 1 - healthy individuals; 2 - first subgroup of patients; 3 - second subgroup.

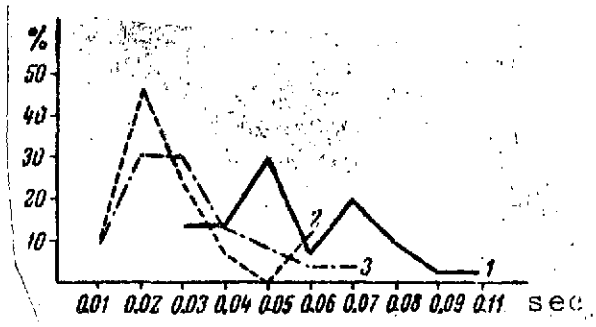

Fig. 2. Distribution of σ. The legend is the same as in Fig. 1.

slowed down (an increase of M) its variability increased (σ increased).

Group of patients. On the CIG curve of patients, there were the same periodic components as for healthy individuals; however, the curves of the majority of the patients varied considerably less.

The RW of the patients had less amplitude and were met less frequently than in healthy individuals; moreover, they were identically frequent in both subgroups. The pronounced nature and character of the RW varied in the majority of patients; while there was a gradual increase of R-R intervals from the previous to the subsequent one in healthy persons, in the group of patients the transitions between the closest intervals were of a "spasmodic" nature. For three patients, it was difficult to identify the small waves transmitted.

In the large contingent of patients in both subgroups, the respiratory arrhythmia was less expressed. Occurrences of expressed RW were met somewhat more frequently in the second subgroup (in 17%), than in the first (in 7.1%).

SW were observed in 28 patients, with identical frequency in both subgroups. In patients with hypertonia, SW-1 took place more frequently than SW-2. This dependence was not noticed among patients without hypertonia. As in healthy individuals, high-amplitude, uniform SW-1 occurred against a high disturbance background. It was not possible to detect these waves during the repeat investigation. /22

One must note the dependence between SW and extrasystole. Out of 21 cases of extrasystole, 14 were accompanied by SW (with identical frequency of SW-1 and SW-2). There was a reduction in amplitude of SW with the disappearance of extrasystole and rhythm stabilization as treatment was carried out (Fig. 3).

Fig. 3. Interval histograms (left) and cardiointervalograms (right) of patient O-, 50 years old. Diagnosis: stage III cancer of the antral section of the stomach, mixed form; stage IIB-III hypertonia. a - Before treatment: partial atrial extrasystole, M = 690 msec, σ = 0.04 sec; b - after pre-operation preparation (papaverine, seduxin [sic], intravenous administration of potassium chloride): the rhythm is stabilized, M = 645 msec, σ = 0.017 sec, there is no extrasystole.

In 23 of the patients, there was aperiodic fluctuation in the CIG curve (in 41% among patients of the first and 23% among patients of the second subgroup). Normally, they had respiratory arrhythmia (Fig. 4, c). Aperiodic fluctuations were met more often in patients with less pronounced pathologic changes. In the first subgroup, these changes were noticed in four patients with hypodynamia, according to data of phase-shift analysis, and in three of them with a relatively variable rhythm (M = 0.7 sec).

Apparently, these fluctuations reflect the condition of cardiac reactance and regulation systems.

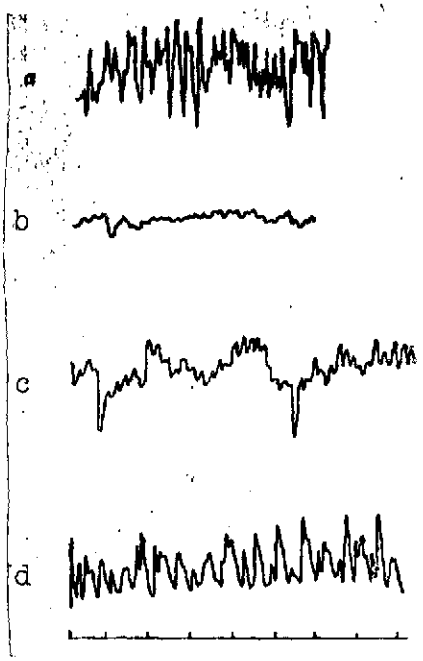

Fig. 4. Views of cardiointervalograms. a - Of a healthy individual A-, 34 years old, M = 965 msec, σ = 0.065 sec, respiratory waves are expressed; b - patient P-, 67 years old. Diagnosis: stage III cancer of the antral section of the stomach, exophytic form; general atherosclerosis, atherosclerotic coronary cardiosclerosis [sic]; hypodynamia syndrome, M = 805 msec, σ = 0.016 sec; c - patient P-, 50 years old, taken 2 years after a myocardial infarction of the anterior septal region with the formation of an aneurism, M = 955 msec, σ = 0.035, expressed RW, SW-2 and aperiodic fluctuations; d - patient Sh-, 54 years old. Diagnosis: cancer of the right mammary gland; stage IIA hypertonia, M = 750 msec, σ = 0.042 sec.

In patients of the first subgroup, M was in the limits 0.610-1.110 sec, when $\overline{M}$ = 0.88 ± 0.14 sec. It was impossible to ascribe two peaks of the distribution curve because of age. Features of the histogram depended on the seriousness of the condition; in the majority of patients with expressed changes of myocardium and hypodynamia (ten out of 14) there was a more variable rhythm (first peak).

On the σ distribution histogram by groups, it can be seen that in patients the rhythm is more stable than in healthy individuals. The most stable rhythm (σ = 0.01-0.02 sec) is seen in patients with marked changes of the contractile capacity of the myocardium. In the majority of patients of the

first subgroup, σ was in the limits 0.009-0.065 sec; with a probability P = 95%, the m e a n value of σ for the subgroup was $0.036 > \overline{\sigma} > 0.002$. In patients of the second subgroup, σ was in the limits from 0.014 to 0.070 sec, with a probability P = 95% $0.043 > \overline{\sigma} > 0.023$. Values of σ = 0.02 and 0.03 sec were met with the same regularity, and a histogram had the form of a plateau. /23

Let us investigate an individual group of patients with a relatively variable rhythm ($\sigma \geq 0.03$). This involves the majority of patients with extrasystole (16 out of 21)[2]. In patient F-, 71 years old, with a Leriche syndrome, the variability of rhythm (σ = 0.061 sec) preceded the occurrence of frequent atrial extrasystole, detected a year after the repeat research.

During the pre-operation preparation, cases were noticed when the rhythm became stabilized and extrasystole disappeared (see Fig. 3).

A relatively high value of σ was noted in patients between 40 and 55 years old, who had suffered myocardial infarction without previous cardiac anamnesis. They showed no changes in the contractile functions of the myocardium, or signs of cardiac insufficiency (see Fig. 4, c).

Finally, one must note the increased variability of rhythm accompanied by a special CIG picture: the brief shift of the average interval value R-R (or the rhythm rate) to a new level, and a sudden lengthening or shortening of 1-2 or a group of adjacent R-R intervals. In these cases to explain the rhythm structure, one must carry out careful study of synchronously recorded CIG, ECG and the breathing curve, since changes in intervals are

[2]In this work, we are concerned with the variability of a basic sinus rhythm; therefore, extrasystolic and postextrasystolic intervals are not investigated.

sometimes linked with respiratory activity.

On a CIG of patient Sh- (Fig. 4, d), there are repeated episodes of lengthening of intervals R-R to 930 msec, with subsequent gradual shortening of R-R to 726 msec, which caused asymmetrical distribution. The dependency between the shape of pinnacle P and the dynamics R-R, and also between intervals P-Q and R-R could not be detected. It is possible that in this case there was a wandering of the controlling pacemaker within the sinoatrical node or a block in the sino-auricular connection. The fact that another group of cells takes on the function of the controlling pacemaker cannot be dismissed, and there is no electrocardiographic picture typical of a sino-auricular block. Let us note that in this patient, there were changes in the specific conducting system of the heart in the region of the right crus of the His bundle.

For explaining further the question of the effect of a basic disease on the structure of cardiac rhythm two much larger groups of patients of approximately the same age were used: with oncologic diseases (25) and atherosclerotic affection of the vessels of the lower extremities (18). Histograms of distribution of σ and M were similar in shape, the mode fluctuated in interval by 0.02-0.03 sec for σ and 0.8-1 sec for M. In both groups, there were patients with a relatively high value of σ and a frequent rhythm. This allowed us to analyze both groups together and calculate that associated diseases and age changes have the greatest effect on rhythm. However, one must not completely ignore the effect of basic surgical diseases on the frequency and variability of cardiac rhythm; this question requires further investigation.

Information obtained confirms that with age and the development of pathological changes, the cardiac rhythm becomes more

stable. There was an especially marked rhythm stabilization in the larger number of patients.

In patients with hypertonia there was a tendency for a more frequent and variable rhythm, in comparison with patients without hypertonia, which was confirmed in data by R. M. Bayevskiy et al.

The group of patients (16), who had suffered myocardial infarction, deserves attention. We observed a respiratory arrhythmia of a higher frequency (50%) than other authors (5.5%, according to /24 data by S.G. Moiseyev and A.I. Bochenkova). This can be explained by improved methods. In a number of relatively young patients, without marked changes in the contractile capacity of the myocardium, the rhythm was variable ($\sigma \geq 0.035$), and the CIG -- similar to that of healthy individuals (see Fig. 4, c).

We did not detect a precise dependence between the expressive nature of the RW and the seriousness of the condition, which was observed by D. Zhemaytite. In some patients with marked pathological changes of the myocardium, there were RW with a stable rhythm background.

The information obtained shows there is rhythm stabilization in a group of patients; however, in a number of middle-aged patients we observed a variable rhythm with large values of σ to values characteristic of young, healthy people. As a result of a histogram (see Fig. 2), they had an overlap zone.

These observations confirm the fairness of Wenkebach, who said that if a "rigid" rhythm shows pathology, a variable rhythm does not mean that the heart is functioning well.

Conclusions

1. Prolonged registration, accurate measurement and statistical processing of a number of R-R intervals makes it possible to determine the characteristic changes of rhythm for individual groups of patients, and to show some features of the rhythm which are missed during normal interpretation of an ECG.

2. In a group of patients there was stabilization of cardiac rhythm, especially when there were marked changes in the contractile function of the myocardium.

3. In the majority of patients with increased variability of cardiac rhythm, during prolonged registration extrasystole appeared, which can be used for checking the therapy used during the pre-operation preparation and during surgical intervention.

4. In patients with ischemic disease of the heart, there is a reduction in amplitude and a change in the character of respiratory waves. The manifestation of respiratory arrythmia does not always correspond to the seriousness of the disease.

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